LIFE HISTORY AND BEHAVIOR OF THE CASE-BEARER *PHEREOECA ALLUTELLA* (LEPIDOPTERA: TINEIDAE)

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Phereoeca Hinton and Bradley (1956) is a genus of tropical moths, the larvae of which are casemaking scavengers that feed on animal hair and dead insects. In a communication to Lord Walsingham (1897) a Mr. Schulz wrote of them: "The Amazonian clothes moth [larval and pupal cases] . . . are very frequent in the houses in Para, keeping on the walls of the rooms and are very injurious to clothes." Although common, associated with human dwellings, and known for more than 80 years, little is known concerning their biology or distribution. Specimens are uncommon in collections. Hinton (1956) described the larvae of three species, but the distinctions among these are not clear and the size of the genus remains uncertain.

This paper, the result of studies done during April through August 1978, is a brief report of the life history and behavior of *Phereoeca allutella* (Rebel) on Barro Colorado Island (BCI), Panamá.

Habitat

Larval and pupal cases (Figure 1) of *Phereoeca* are found on the outside walls and inside non-airconditioned buildings on BCI. They are most abundant under spiderwebs, in bathrooms and bedrooms. (BCI residents refer to them as "bathroom moths.") Adults may be seen flying or resting in these same areas as well.

Speculation as to where *Phereoeca* would live, if buildings were not available, lead to a fruitless search for it in other habitats. They were not seen in three years of BCI berlese sampling of leaf litter (Sally Levings, pers. comm.), or on tree trunks or buttresses. The larval cases would be well camouflaged if they rested on tree trunks;

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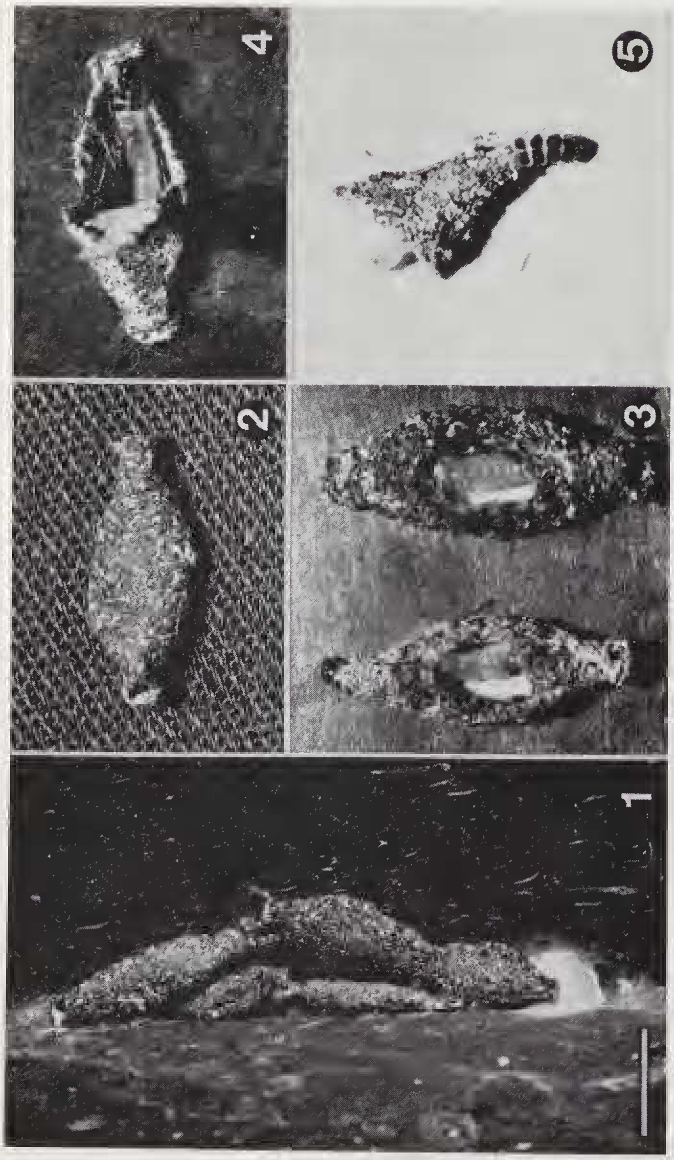
they turn dark when wetted, as does bark, and become light again upon drying. Possibly *Phereoeca* may be associated with mammals other then man. Bat roosts should be checked for the presence of larval cases.

Case Form and Function

The larval case of *Phereoeca* is flat, spindle-shaped in outline, open at both ends, silk-lined inside, and covered with sand and other small particles outside. It is constructed by the first instar larva soon after hatching, is enlarged by each successive instar, and after special modification, is used for pupation. Fully formed cases are 8–13 mm long and 3–5 mm wide. Once a larva has completed its case, it never leaves; all life functions (feeding, excretion, molting, pupation) take place within the case. When prodded from its case, a larva does not re-enter it, nor does it make a new one. It wanders about, does not eat, and dies in a day or two. Such larvae often walk right over their cases without seeming to recognize them. Larvae occasionally paused upon encountering the inside silk portion of cases which I had split open; however, after a few seconds of exploration, they continued wandering. Larvae placed into cases, through a slit made in one side, repaired the slit and continued to live in the case as if nothing had gone wrong. They also accepted the cases of other larvae as their own.

The case is the same on both sides; it does not matter whether it is flipped over or not. The two openings are also identical, and the larva uses both. The case is widest in the middle permitting easy turn-around inside. Larvae behave as though they don't notice being upside down until they poke their heads out of their cases. If the case is flipped over while the larva is withdrawn, it next appears upside down, withdraws into the case, swivels around inside, and reappears right-side-up.

When disturbed, the larva withdraws into the case and seals it by pulling the bottom-most side up. Presumably this is done using the mandibles. If it is then flipped over, allowed to come out, and disturbed again, it pulls up the "new" bottom-most side (Figure 2). The closed ends are very difficult to open from the outside, but easily pushed open from within. They stay open when pushed open, and closed when pulled closed, because both positions are stable. This phenomenon can be demonstrated by pushing in the ends of a paper tube, such as the core of a paper towel roll.



Figures 1–5. *Phereoeca allutella*. 1. Group of pupal cases attached to wall in a corner. Scale = 6 mm. 2. Larval case with one closed end up (left). 3. Two larval cases with windows. 4. Case slit open to show larva and food (human hair). 5. Larval case cut in half for study of locomotion.

In order to see larval behavior inside the case, I installed windows (Figure 3). A rectangle was cut from one side of each of several cases; a piece of clear lightweight plastic was then glued over each hole. I observed turning movements, feeding, excretion, molting, and pupation through these windows.

To turn around inside the case, the larva withdraws until its posterior end reaches the constriction leading to the opening at the other end, then turns its head to one side and doubles back on itself. When its head has moved past the midpoint of the case, it straightens its posterior end to complete the turn.

Upon encountering food (dead insects, animal hair), the larva chops it into pieces and pulls it into its case. Feeding takes place only within the case. Larvae reared for study were fed dead mosquitoes and my hair (Figure 4). The larva never protrudes its posterior end outside. It defecates inside the case, then turns around inside and pushes the droppings out with its head.

Molting also takes place within the case. The larva retreats into its case and does not emerge again for about 24 hours. After ecdysis, it turns around and pushes the shed skin and head capsule out, using its head.

Locomotion

Phereoeca larvae have two main types of locomotion; one concerned with movement about the habitat while pulling the case behind, the other with movements inside the case.

The prolegs of *Phereoeca* are somewhat reduced, but crochets can be seen under a microscope. That the tenth segment prolegs are used to grip the case when moving was demonstrated by several simple experiments. I cut a case in half transversely so that the larva's head and thorax stuck out of the neck and its posterior end protruded from the large cut end (Figure 5). When it tried to walk and pull its case, the larva went nowhere because it held onto the table with its tenth segment prolegs. When I positioned the loose half of the case against the larval half so that the cut edges came together, the larva held onto the loose half with its tenth segment prolegs, and walked around pulling both halves of the case behind. I then covered the tenth segment prolegs with Elmer's Glue-all® and the larva was no longer able to pull the loose half of the case behind it. However, it was able to pull the front part of the case, indicating that other prolegs are probably involved as well. The body setae are weak and probably play no role in holding the case.

To move about the habitat, the larva extends the anterior part of its body out of the case, walks ahead with its true (thoracic) legs, then stops and contracts its body to pull the case up behind. When moving at top speed (one pull per second), a larva progresses 1–2 mm per second on a horizontal surface, and only slightly slower on a vertical one.

When moving within the case, the larva uses both true legs and prolegs, plus body extension and contraction, in typical larval fashion.

Larvae

Larvae chew their way out of their eggs eleven days after oviposition. The head is dark; the rest of the larva is white. From the second instar on, the tergal and pleural sclerites of each thoracic segment are sclerotized and dark, perhaps as protection when the larva reaches out of its case. The final instar larvae of three species of *Phereoeca* were described in detail by Hinton (1956).

Individuals closely monitored during development passed through six larval instars. First instar larvae had head capsule widths of 0.16–0.18 mm. Head capsule width increased with each molt by an average factor of 1.34 (range: 1.22–1.46). Final head capsule widths ranged from 0.66 mm to 0.78 mm. However, these were all males. Larvae of females, collected as final instars, were larger and had head capsules as wide as 1.06 mm. Apparently females either grow more than males from one instar to the next, or attain a seventh instar. Possibly instar number varies among individuals of both sexes.

Case Construction

Soon after leaving the egg, the larva begins to construct a case of silk and tiny particles such as sand, soil, and insect droppings. It begins by constructing an arch attached at both ends to the substrate. The arch, which consists of silk on the inside and particles on the outside, is gradually extended to form a tunnel within which the larva is concealed. Finally the larva closes the tunnel beneath to form a tube, open at both ends, and free from the substrate. With the first case complete, the larva is able to move about, pulling its house behind it, in search of food and resting places. This first case is about 1.5 mm long. The smallest individuals initially construct a case that is round in cross section, while the majority of individuals produce a somewhat flattened one. Larvae that fail to make cases never feed, and die within a few days.

Case Enlargement

As the larva grows and molts, it enlarges its case to 8–14 mm in length. Beyond the first instar, the case is always flattened, and is spindle-shaped in outline.

In order to determine just how each instar contributes to the formation of the case, I provided two larvae with colored particles for case construction and, during each molt, replaced them with particles of a different color. Three colors were used: red (powdered brick), brown (sand), and black (iron removed from sand with a magnet). The discarded head capsules were collected after each molt to verify the molt and to obtain a measure of growth.

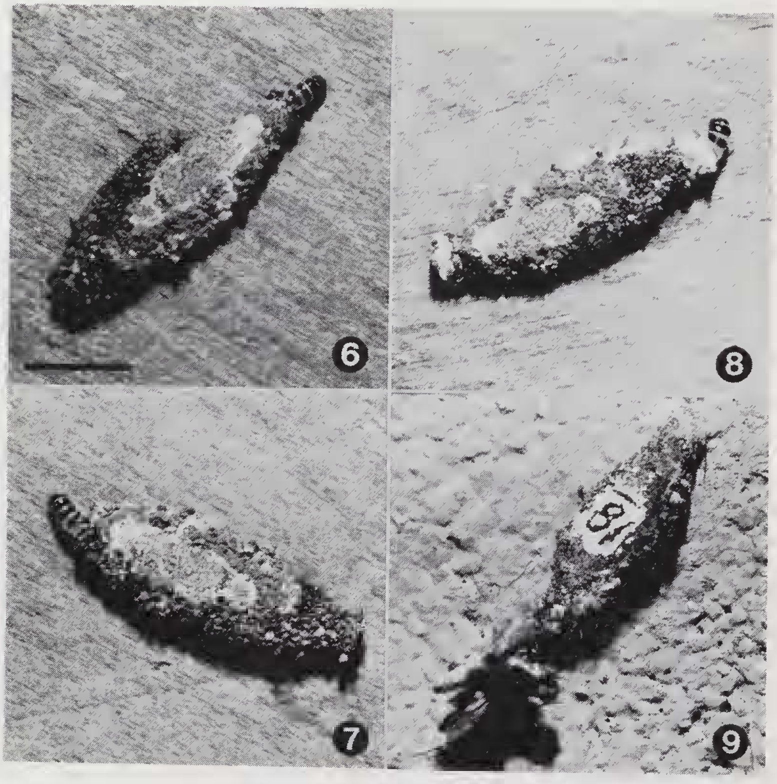
To enlarge its case, the larva first adds a narrow band of new material to both ends. Then, beginning at one end, it slits the case open along one edge for a short distance, and widens it by adding extra silk and new particles which it picks up with its mandibles. The larva continues slitting the case and adding material along one side until it reaches the other end. It then adds extra material to that end and continues the process along the other side of the case (Figures 6–8).

Each instar, from the second through the next to last, adds once to the case as just described. The final instar adds a thin band of new material to both ends of the case, but does not widen it.

Movements about the Habitat

In order to follow the daily movements of individual larvae, I numbered the cases of 34 larvae in the bathroom of Barbour House on BCI using typewriter correction fluid (Liquid Paper®), and permanent ink (Figure 9). The cases marked ranged in length from 3 mm to 14 mm. Each was returned to its former location. The positions of these larvae were noted at approximately twelve noon and twelve midnight daily for the following two and a half weeks.

In general, larvae foraged and added to their cases along the floor-wall junctions, or out on the floor at night, and rested at the bases of the walls or up several centimeters on them during the day. Occasionally a larva was seen moving about during the day. Usually each larva returned to, or near to, the spot where it had been recorded the day before. Most stayed within 30–80 cm ranges, with an occasional sudden change from one wall to another. For example, individual "6" was frequently found out on the floor at night, but rested against the wall under the sink by day. After ten days of



Figures 6–9. 6. Larval case (rearing lot 78-5) (25 April 1978) with new material (dark) added to one side and halfway along other side. Scale = 3 mm. 7. Same case (27 April 1978) with enlargement completed. 8. Same case (next instar) (11 May 1978) with further material (white) added to both ends and part way along one side. 9. Individual number "18" eclosing.

this pattern "6" moved into a nearby corner. The greatest minimum distance moved from one day to the next was 228 cm (partly horizontal, partly vertical).

Among eighteen individuals studied in detail, the average distance travelled per 24 hour period was 42.4 cm (range: 13.7–108.7 cm). Nine of these individuals pupated during the study; in each case, pupation was preceded by a horizontal wandering phase of 0.5–2.5 days and a period of vertical movement lasting 0.5–2 days. All nine larvae attached their cases to the wall at heights from 64 cm to 244 cm, and prepared for pupation.

Pupation

When a larva approaches pupation, it usually walks up a vertical surface and attaches its case firmly with silk at both ends. It then modifies one end of the case by cutting a short slit along both edges of that end. An end thus modified becomes much flatter and is no longer pulled shut by the larva. It acts as a valve; very difficult to enter but easy for the adult to exit through at eclosion.

With its head, the larva next pushes all remaining food and other debris out of the case. A day or two later, it molts to a pupa, pushing the last larval skin and head capsule into the unmodified end of the case (Figure 10).

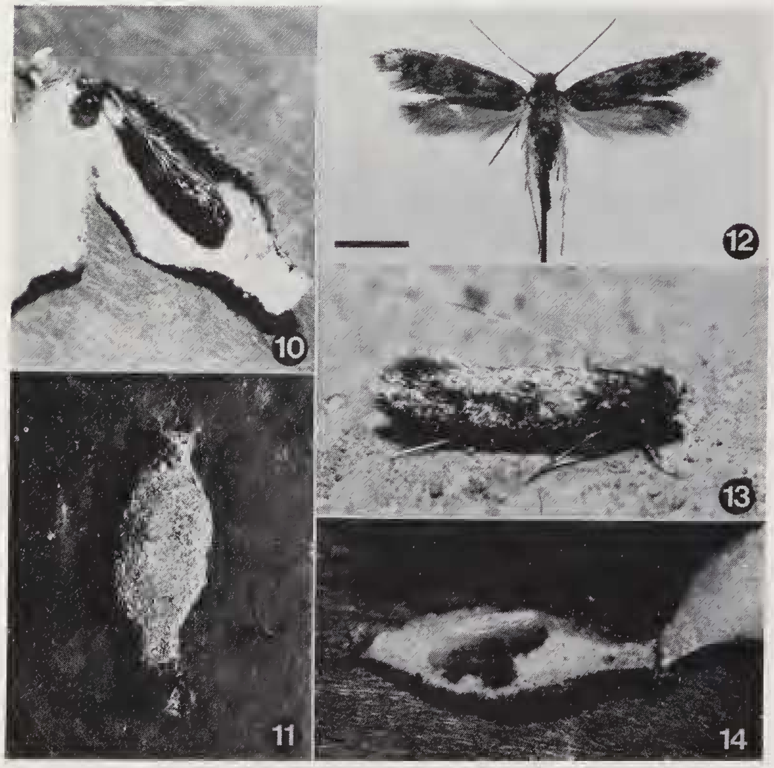
Of 73 abandoned pupal cases examined, the average height from the ground was 87.7 cm (range: 0–214 cm). There was no relationship between the height from the ground at pupation and either case size or sex. Of these, 63 cases were attached vertically, 59 (of the 63) with the head down, and 56 (of the 73) with the ventral side of the pupa towards the wall.

Pupal cases are easily distinguished from cases of resting larvae. The larval case is held very loosely to the wall with several almost invisible silk strands at the upper end; the pupal case is held firmly by a great deal of silk at both ends. After eclosion, the empty pupal skin projects from one end (Figure 11). Most cases seen on walls are actually abandoned pupal cases, but often the pupal skin has been eaten flush with the case by other *Phereoeca* larvae, making it difficult to tell that a case is no longer occupied.

Based on 22 reared individuals, the pupal period averages 15.6 days (range: 11–23 days). The entire cycle from egg to adult averages 74.2 days (range: 62–86 days). Among those reared, males matured before females and outnumbered them 19:3.

ECLOSION

Eclosion takes place during late morning or early afternoon. The pupa wriggles head first part way out of the valve, and the adult emerges from the pupal skin (Figure 9). While the wings are expanding, they are held upwards, perpendicular to the body, but after sufficient expansion and hardening, they snap down over the abdomen.



Figures 10–14. 10. Pupal case slit open to show pupa and cast larval skin. 11. Abandoned case with pupal skin protruding. 12. Adult female (mother of rearing lot 78-99). Scale = 2.5 mm. 13. Wild adult resting. 14. Pupal case slit open to show parasitoid cocoon (Braconidae) and remains of host larva.

Adults

Adult females (wingspan: 10–13 mm) (Figure 12) are grey with one to four black spots on the forewings, and a fringe of scales along the posterior margin of the hind wings. Males (wingspan: 7–9 mm) are slightly smaller and have a less distinct wing pattern.

When the adult is at rest, the wings are held tented over the body (Figure 13). The antennae, which are almost as long as the wings, are held back over the body and vibrated constantly.

While adults fly fairly well, they spend much of their time resting on walls, floor edges, or on the webs of theridiid spiders. Adults have reduced mouthparts, and have not been seen to feed.

Mating

During late evening, the newly eclosed female protrudes membranous calling organs from the tip of her abdomen. Males are attracted to "calling" females; their behavior at this time consists of maneuvers for orientation to the female, rather than for courtship. A male flies to a "calling" female, lands near her, runs rapidly about her, then bumps against her abdomen with his head several times before turning suddenly and copulating with her. During copulation, the male ceases antennal vibration, but the female continues it. The pair remains coupled for about thirty minutes.

EGGS

Within several hours of mating, the female begins to lay eggs, cementing them to debris along the bases of walls and in crevices. One female may produce as many as 200 eggs over a period of several days, before dying about a week after eclosion. Unmated females may lay sterile eggs beginning the day after eclosion. Eggs are about 0.4 mm in diameter, pale bluish, and very soft. It is virtually impossible to move them without rupturing them. After ten days, the head of a larva can be seen faintly through the egg wall.

Braconid Parasitoid

Last instar larvae may be preyed upon by *Apanteles* sp. (Hymenoptera: Braconidae). The larva is killed just before pupation; its case is full-sized, and in most instances has already been modified for pupation. The larval remains can be found inside with the white silk cocoon of the wasp (Figure 14).

Discussion

A number of Lepidoptera and Trichoptera make movable cases during larval life. In the Lepidoptera, movable cases are found in several families (e.g., Psychidae, Tineidae, Mimallonidae, Stenomidae), and vary among taxa, as to size, shape, and materials. They may be conical, oval, circular, spindle-shaped, dumbell-shaped, or irregular in outline, and round, flattened, or triangular in cross section. There may be an opening at one or both ends, and the case may have either a definite dorsal and ventral side or the sides may be interchangeable. Construction materials may include soil, frass, twigs, food particles, leaves, or organic debris, but always include silk. Among lepidopterous cases examined, the only ones resemblng those of *Phereoeca* belonged to several other species of Tineidae. Of these only *Tinea pellionella* (the case-making clothes moth) has been studied in detail (Réaumur 1737, Marlatt 1898).

The case of *Tinea pellionella* is like that of *Phereoeca* in having two openings and no definite dorsal or ventral side; it differs in being less flattened, in being constructed of food particles (wool), and in the method of case enlargement used. The larva makes a slit along one side of the case from one end to about the middle. It adds a wedge of new material to the slit, and repeats the process on the other side at the far end.

The cases of Trichoptera larvae also are made from silk plus materials collected from the habitat. Hanna (1960) described eight construction patterns used by Trichoptera larvae when making their initial cases. None of these in any way resembles the method employed by larvae of *Phereoeca*.

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